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The Bathurst Mining Camp

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THE BATHURST MINING CAMP

The N.E.I.G.C. field trip to the Bathurst-Newcastle area will provide those interested in mining geology an opportunity to study massive stratiform sulphide deposits and the general aspects of the geological environment in which they occur. Limitations of time confine the excursion to the immediate area of three of the largest of the known deposits: Brunswick No. 12, Brunswick No. 6 and Anaconda Caribou.

REGIONAL GEOLOGY

The massive sulphide bodies occur in a highly deformed volcanic pile which underlies over 700 square miles of northern New Brunswick. The general geology is indicated in Fig. 1 which also shows the location of significant deposits. The pile includes sedimentary rocks, gabbroic and dioritic intrusions, at least one ultramafic plug, and later Devonian granite stocks and batholiths.

The volcanic (units 0_2, 0_3, and 0_4 in Fig. 1) and the enclosing meta-sedimentary rocks have been generally included in the Tetagouche Group and assigned a middle Ordovician age on the basis of one or two fossil localities, both of which occur near the periphery of the outcrop area. Recent structural studies have suggested that the bulk of the volcanic rocks and associated sedimentary rocks, including the indicated deposits (except Nigadoo) may be older.

The stratigraphy of the pre-Silurian rocks is summarized below:

Ordovician (in part Middle Ordovician)	Tetagouche Group	tuff, flows, quartz-sericite schist, biotite-chlorite schist; minor slate and mafic metavolcanic rocks.
		Augen schist: quartz and quartz-feldspar augen schist, quartz-sericite schist, quartz-chlorite (biotite) schist; minor mafic metavolcanic rocks, and metasedimentary rocks.
		Metasedimentary rocks: (a) phyllitic slate, argillite, greywacke, siliceous argillite;

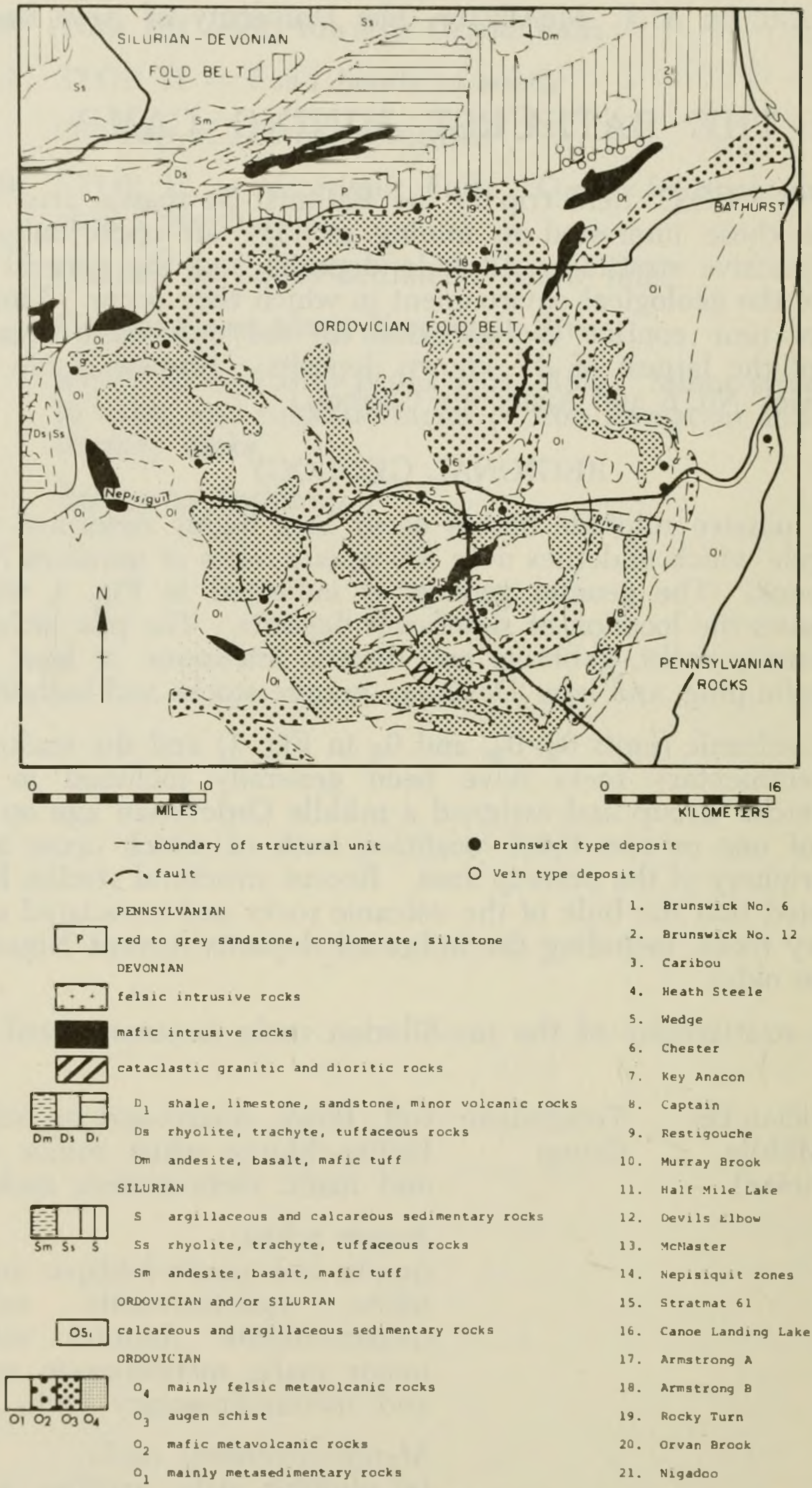

Fig. 1 General geology Bathurst-Newcastle mining district (J. L. Davies).

(b) feldspathic sandstone, quartz-chlorite and quartz-sericite schist, minor slate.

Mafic metavolcanic rocks:

(a) spilite, greenstone, minor trachyte and metasedimentary rocks;

(b) greenstone, mafic metatuffaceous rocks, red and grey slate and phyllite.

Intense structural deformation coupled with low grade metamorphism is a characteristic feature of the rocks older than Silurian. Steep isoclinal folding has been produced during one and possibly two periods of orogeny, and deformation of lesser intensity has been superimposed upon them.

Studies of minor structures, carried out in widely separated parts of the camp, have indicated at least three periods of deformation and as many as six (Helmstaedt 1970, Fyffe 1970, McBride 1973, Luff 1973). The relationship of the individual deformational periods to the Taconic and Acadian orogenies is not clear, but the earlier periods produced the isoclinal folds and a strong schistosity. Later phases resulted in broad open folds with prominent fracture or crenulation cleavage and kink bands.

Stong transcurrent faults striking N70-80°E having right-hand displacements of up to fourteen miles have been mapped. A second set of faults strikes between north and northwest.

SULPHIDE DEPOSITS

The three deposits, Anaconda Caribou, Brunswick No. 12 and Brunswick No. 6 are typical of the many sulphide deposits of the volcanic pile. They are generally concordant, fine grained, pyrite-sphalerite-galena - chalcopyrite - pyrrhotite bodies, occurring in sedimentary rocks at or near their contact with a quartz-feldspar - augen schist which is generally interpreted as ash-flow tuff.

Two types of mineral assemblage are found:

1) Massive pyrite, commonly imperfectly banded, containing sphalerite, galena and minor chalcopyrite and pyrrhotite with small amounts of arsenopyrite and tetrahedrite-tennantite.

2) Pyrrhotite-chalcopyrite assemblages as lenticular zones containing veins and pods of massive sulphides.

The sedimentary rocks near ore bodies are most commonly iron-rich chlorite schists, iron formation and chlorite-sericite-(biotite) schist but sericite schists, chert and dark argillites are also found. Barite and siderite are found in places.

Brunswick No. 12 Mine: (After D. Rutledge, 1972) The general geology of the Brunswick No. 12 Mine is indicated in Fig. 2, and in the table of formations as follows:

Table of Bedrock Formations
Near Brunswick No. 6 and No. 12 Mines

Period or Epoch	Group	Lithology
Ordovician (?)		Quartz-feldspar porphyry dyke Metadiabase and metagabbro
	Intrusive Contact	
Ordovician (?)	Tetagouche	a) Upper volcanic rocks b) Iron formation (including sulphides) c) Augen schist d) Metasedimentary rocks.

The beds lie in tight isoclinal folds with axial planes striking northwest and dipping steeply west. A later stage of folding has axes plunging steeply to the west. The folds are cut by faults which strike northwest roughly parallel to the ore body and schistosity of the enclosing rocks.

The No. 12 Main Zone is a roughly lenticular mass which fingers out at the ends. The deposit strikes north-south, dips about 75 degrees west and plunges almost vertically. At surface the sulphide body is 1300 feet (395 m) long and 100 to 200 feet (30-60 m) wide. About two-thirds of the sulphide mass in the upper part of the mine is lead-zinc ore, the remainder being essentially massive pyrite. With increasing depth, the size of the pyrite body becomes greater without reduction of volume of lead-zinc ore.

The West Zone dips steeply westward but steepens to almost vertical at a depth of about 1900 (575 m) feet, and thus gradually converges with the Main Zone. The West Zone apex is about 350 feet (105 m) below surface and it continues to a depth of 3400 feet (1030 m) with no apparent diminution in size and grade.

The sulphide deposits consist of 80 to 90 per cent of predominantly fine-grained sulphides, mainly pyrite, sphalerite, galena, chalcopyrite, tetrahedrite and bornite. Small amounts

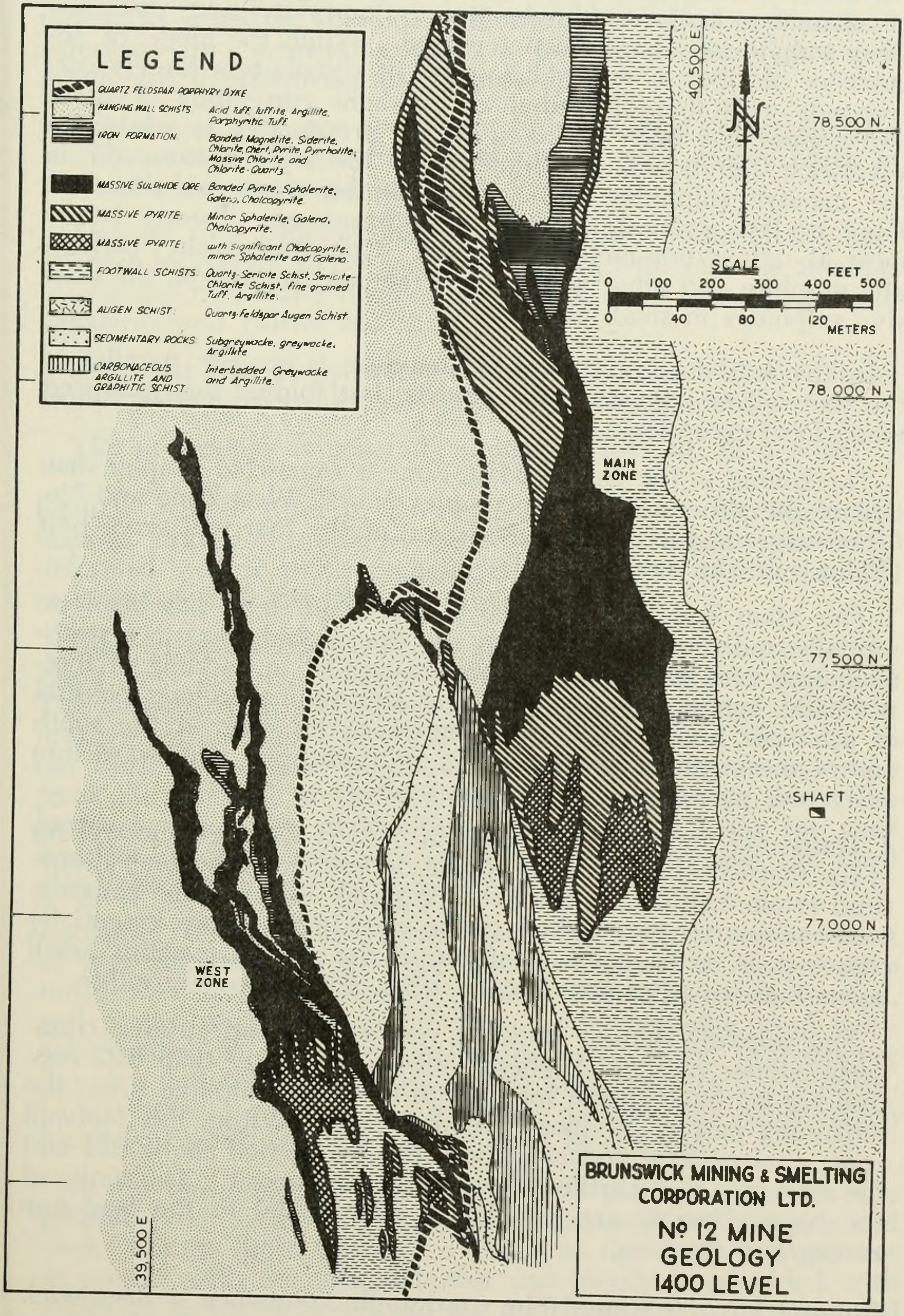

Fig. 2 Geological plan, 1400 ft. level, Brunswick No. 12 Mine.

of stannite, cassiterite, boulangerite, domeykite and unnamed silver sulpho-salts have been reported. While the mode of occurrence of silver is not well known, its distribution largely corresponds with that of lead-zinc. A slight correlation of silver and copper has been observed which presumably is related to silver-rich tetrahedrite. Magnetite is relatively uncommon in the massive sulphides, but is considerably more abundant in more or less isolated lenses of iron formation. Quartz is the most abundant non-metallic mineral. Chlorite, sericite, carbonate, graphite and other gangue minerals are common in the massive sulphides in small amounts.

In the lead-zinc ore, sulphide banding is usually parallel to the footwall or hanging wall contacts, but folding has produced many local exceptions.

The zoning in the No. 12 Main Zone is somewhat simpler than that of the structurally more complex No. 12 West Zone and No. 6 orebody and therefore a description of the first will serve best to illustrate the general pattern.

The Main Zone on the 1900 foot (575 m) level has been essentially undisturbed by folding, and the sulphide mass is a stratiform lens with banding of sulphides parallel to bedding of footwall and hanging-wall rocks. The longitudinal zoning consists of a simple, fine-grained non-foliated, pyrite mass at the south end of the sulphide body, grading quite abruptly northward into a layered, pyrite-sphalerite-galena orebody.

Transverse zoning has resulted in highest tenor Pb, Zn and Ag in the footwall third of the sulphide deposit, with the central one-third to one-half somewhat lower in grade. Toward the hanging-wall one-quarter to one-third of the mass is of sub-ore, essentially copper-poor, commonly colloform, pyrite which contains small layers and lenses of fine-grained silica and siliceous argillite.

The sulphide deposit shows a very simple and striking transverse copper zoning. Highest Cu values (greater than 0.2% copper) are confined to the footwall third of the sulphide mass, the remaining part of the mass is copper-poor. Within this footwall zone, chalcopyrite, occurs in both the pyrite rich south end and the lead-zinc rich northern portion of the deposit. The limits of the copper zoning are parallel to sub-parallel to the lead-zinc zoning and layering.

Brunswick No. 6 Mine: The stratigraphic sequence at Brunswick No. 6 Mine is generally similar to that at Brunswick No. 12, in that a thick layer of ash flow material, now deformed to augen schist, is overlain by a zone of chemically precipitated sedimentary rocks including sulphides, chlorite schist, chert and oxide – carbonate iron formation, which is in turn overlain by a primarily volcanic sequence (see Figure 3).

The beds in the ore zone form tight isoclinal folds plunging steeply south in the north half of the pit and steeply north in the south half of the pit.

The ore zone contains massive fine-grained pyrite at the base overlain by layered pyrite galena-sphalerite with variable amounts of chalcopyrite, and a hanging wall pyrite zone containing minor sphalerite and galena and little copper.

A tabular heel of pyrrhotite-chalcopyrite extends down plunge from the thick footwall pyrite into the footwall rocks.

The mineralogy is generally similar to the No. 12 deposit.

Caribou Mines: (After R. Cavalero, 1970) At the Caribou mine massive stratiform sulphides occur around a broad open well-deformed steeply north plunging synform over a strike length in excess of 4000 feet (See Figure 4).

The Caribou deposit occurs within the metasedimentary rocks along their northern contact with a potassic volcanic sequence. The deposit consists of three tabular, steeply-dipping, stratiform massive sulfide lenses arranged en échélon around the nose of the Caribou synformal fold, so that the metasedimentary rocks form the footwall of the orebody and the volcanic schist the hanging wall. Two of the sulfide lenses occur along the west limb of the fold (north and south sulfide bodies) and the third along the east limb (east sulfide body).

Enclosing Rocks: The footwall metasedimentary rocks consist of two dominant types. Immediately adjacent to the massive sulfide bodies is argillaceous phyllite, normally quartz-banded, and pyritic toward the sulfide zone and containing local lenticular bodies of chlorite-pyrite-(chalcopyrite) schist. Enveloping this unit and delineating the Caribou fold structure is a relatively homogenous zone of fine graphitic phyllite and schist which has been traced well beyond the limbs of the fold.

In the nose of the fold gray pelitic phyllite separates the graphitic zone from the andesitic rock sequence to the south and west. On the limbs this unit is absent as the graphitic rocks are in contact with the meta-andesites and locally interbedded with andesitic metasiltstone toward the anticlinal hinge. A thin band of altered gabbro occurs within the graphitic zone and appears

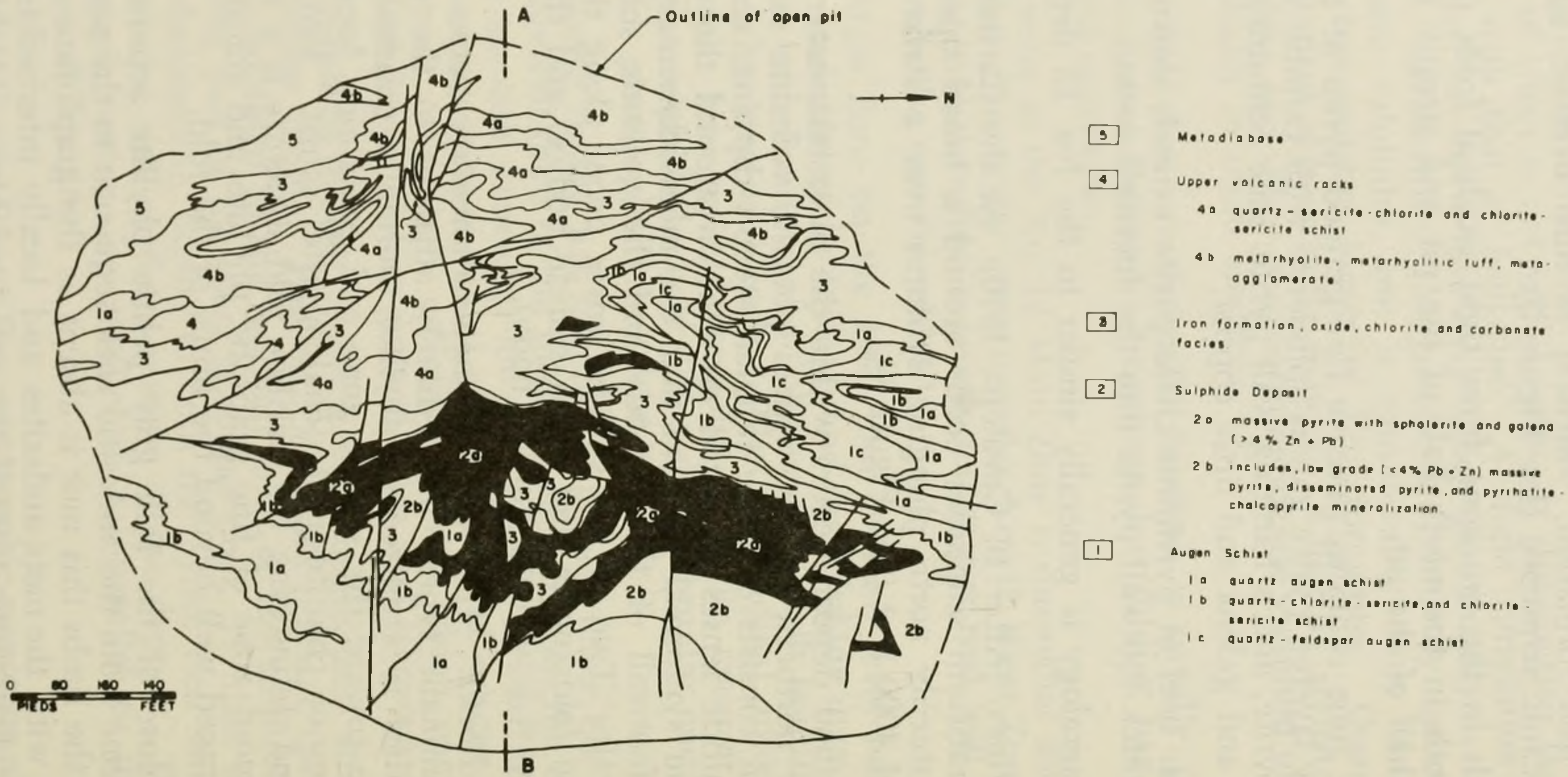

Fig. 3 Surface plan, Brunswick No. 6 Orebody, (Z. Pertold, unpub.).

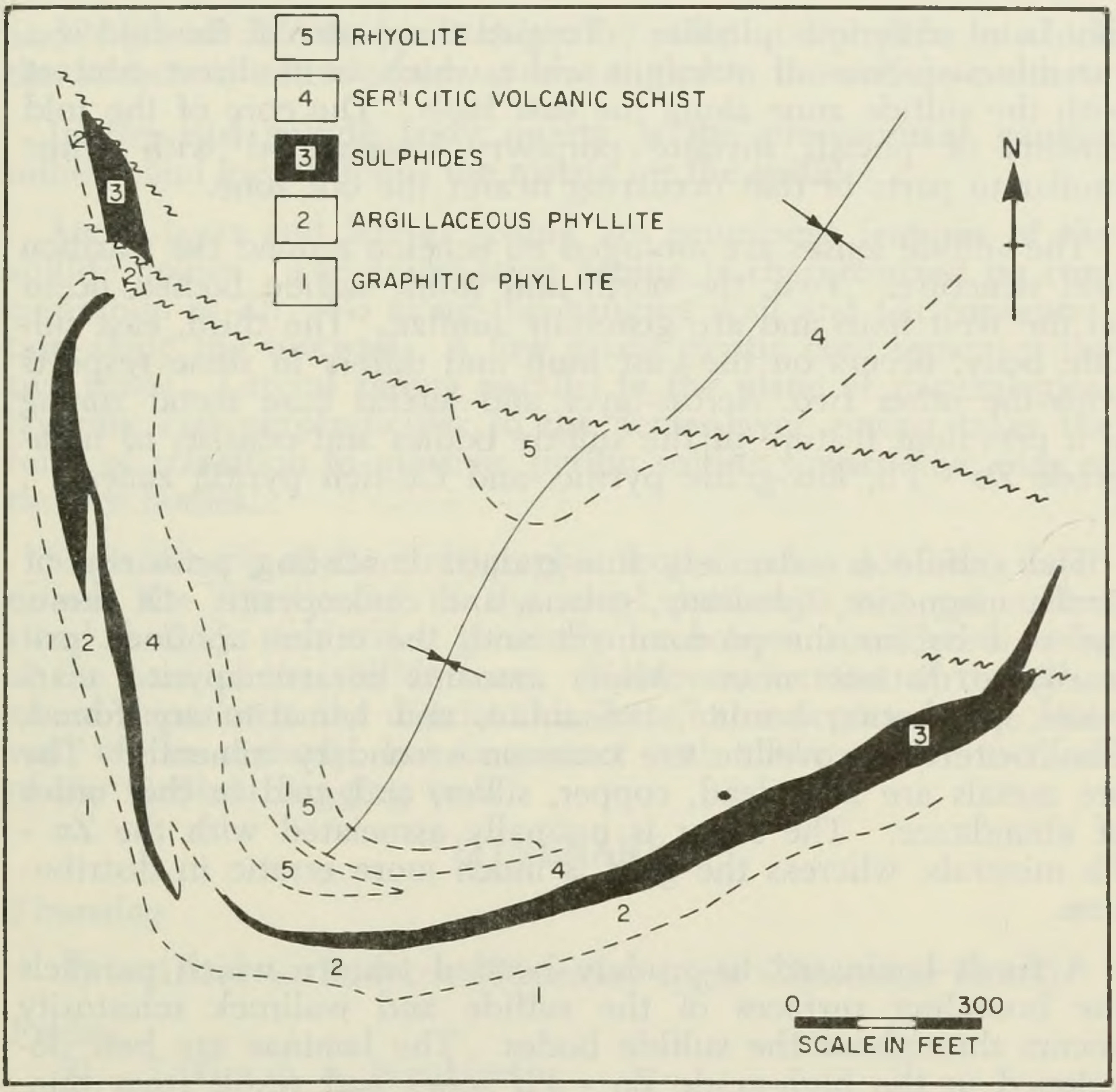

Fig. 4 Plunging synform, Caribou Mines.

to be a pre-fold sill-like intrusion. Outcrops of inclusion-bearing aplitic granite also occur between the gabbro and meta-andesite on the east limb.

Along the south half of the north sulfide body occurs a lenticular, heavily pyritic chloritic unit. It pinches out adjacent to the sulfide mass to the north and into the footwall phyllite to the south attaining a maximum width of 25 feet.

Adjacent to the south sulfide body and extending approximately 200 feet along its center is a disc-shaped lens of chloritic rock rich in chalcopyrite. The lens rarely exceeds 10 feet in width and has a down-dip length of nearly 400 feet.

Three dominant rock types occur on the hanging wall. Adjacent to the massive sulfide on the west limb of the fold is a thin band of sericite phyllite. Toward the center of the fold is a variable sequence of volcanic schist which is in direct contact with the sulfide zone along the east limb. The core of the fold consists of potash rhyolite porphyry intercalated with schist similar to parts of that occurring nearer the ore zone.

The sulfide lenses are arranged en echelon around the Caribou fold structure. Two, the north and south sulfide bodies, occur on the west limb and are generally similar. The third, east sulfide body, occurs on the east limb and differs in some respects with the other two. Across-layer and lateral base metal zoning is a prevalent feature of the sulfide bodies and consists of high-grade Zn - Pb, low-grade pyritic, and Cu-rich pyritic zones.

The sulfide is extremely fine-grained consisting primarily of pyrite, magnetite, sphalerite, galena, and chalcopyrite. Of these, pyrite is by far the predominant with the others confined primarily to distinct zones. Minor amounts of arsenopyrite, marcasite, pyrrhotite, bornite, tennantite, and hematite are found. Chalcocite and covellite are common secondary minerals. The ore metals are zinc, lead, copper, silver, and gold in that order of abundance. The silver is normally associated with the Zn - Pb minerals, whereas the gold is much more erratic in distribution.

A finely-laminated to crudely banded texture which parallels the bounding surfaces of the sulfide and wallrock schistosity occurs throughout the sulfide bodes. The laminae are best developed in the high-grade Zn - Pb zones and result from thin, sphalerite-rich bands commonly sinuous and irregular, but fairly continuous. Within the bands sphalerite forms the matrix as irregular grain clusters. A crude banding is also exhibited in the low-grade and cupriferous pyritic zones resulting primarily from grain size variations in adjacent bands.

A third form of banding results from magnetite which occurs locally in distinct zones of irregular distribution commonly overlapping the base metal zones. The mineral, in concentrations up to 30 per cent is very fine-grained and occurs as long, sinuous laminae, irregular bands and lenses, and vermicular patches. Magnetite is abundant in the south sulfide body and north half of the north sulfide body, but occurs very locally in the east sulfide body. It has not been recognized in the wallrocks or waste bands within the massive sulfide.

Chlorite is the predominant gangue mineral in the north and south sulfide bodies. Less common are fairly continuous bands and lenses of chlorite-(quartz)-(pyrite) schist and phyllite in which the schistosity often occurs at low angles to the sulfide contacts.

In the east sulfide body quartz is the predominant gangue mineral and locally forms the matrix for the sulfides.

Across-layer and lateral zoning are prominent features of the sulfide bodies. The across-layer zoning is characterized by concentration of Zn - Pb along the hanging wall and Cu concentration along the footwall. A low grade pyritic core separates the two zones. Lateral zoning parallel to the plane of mineralogical layering and perpendicular to the across-layer zoning takes the form of transition to massive, pyritic sulfide toward the ends of the ore bodies.

Since the top of the stratigraphic sequence has not been determined, the significance of the zonal pattern is not yet understood, but Cu-rich zones generally have been considered to lie at the base of the sulfide mass. However, in most of the other zoned deposits in the district this "base" also occurs on the footwall of the orebody, but in contact with rocks similar to those of the Caribou hanging wall.

ITINERARY

Thursday

1) Arrive in Bathurst (Thursday night Gloucester Hotel)

Friday

2) 7:00 a.m. – breakfast
3) 8:00 a.m. – leave for Brunswick No. 12
4) 8:30 a.m. – briefing at No. 12
5) 9:30 a.m. – underground
6) 12:30 p.m. – lunch
7) 1:30 p.m. – Brunswick No. 6, Austin Brook, Nepisiguit Falls
8) 6:00 p.m. – return to Bathurst
9) 7:00 p.m. – dinner

Saturday

10) 7:00 a.m. – breakfast
11) 8:00 a.m. – leave for Brunswick No. 12
12) 8:30 a.m. – tour of mill
13) 11:00 a.m. – leave for Heath Steele
14) 12:00 p.m. – lunch
15) 12:45 p.m. – surface tour – structure, stratigraphy
16) 3:00 p.m. – leave for Fredericton
17) 6:00 p.m. – arrive in Fredericton